RECHARGE POLICY ANALYSIS: MONEY, FACILITIES AND CHOICES IN THE TUCSON ACTIVE MANAGEMENT AREA[1]

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Introduction

Effective regional recharge planning requires consideration of interrelated hydrologic, economic, institutional and political factors. The number and complexity of those factors can create an impediment to reaching specific policy recommendations. In spring of 2000, the Tucson Active Management Area's Institutional and Policy Advisory Group (IPAG) faced precisely that dilemma as it attempted to address a relatively narrow question related to the financing of recharge infrastructure. At issue was whether to support a proposal in which the Arizona Water Banking Authority (AWBA) would indirectly finance a pipeline that would bring CAP water to a permitted Groundwater Savings Facility (GSF).

Although there were questions about the proposal itself, almost immediately a range of broader policy issues arose. *Is additional recharge facility capacity needed? Do storers' plans match existing and proposed facilities? What role should recovery play in storage decisions? Will the AWBA's revenues be sufficient to meet its obligations?*

Initial discussion of these and related questions revealed the substantial diversity of background, perspective and knowledge among the IPAG participants. It was apparent that if consensus recommendations were to be reached, a common base of knowledge and an analytical framework would need to be established. IPAG would be assisted in that task by a customized decision-support tool that helped the group test and evaluate potential policy options.

History of IPAG

IPAG was formed as part of an ambitious recharge planning process that began in the fall of 1995. The Regional Recharge Planning Process involved the Regional Recharge Committee (entirely technical experts), and IPAG (policy-oriented representatives). Staff from the Arizona Department of Water Resources' Tucson Active Management Area provided support and coordination. The Regional Recharge Committee produced a Technical Report (1996) with physical data that served as the foundation IPAG then used to evaluate the institutional, political and economic

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components of regional recharge. IPAG embarked on an extensive process that included a needs assessment and development of evaluation criteria for existing, planned and proposed recharge projects

In a related effort, in 1997 IPAG provided input to the AWBA's statutorily mandated plan for additional storage facilities in the Tucson AMA (AWBA, 1997). IPAG submitted a Report (1997) with advice on meeting groundwater management objectives and an analysis of recharge sites. The need for the plan had been triggered by another statutory provision that required the AWBA to "…prepare and assess an inventory of existing storage facilities in this state to determine whether existing storage facilities are available to meet the authority's need for the following ten years" (A.R.S. 45-2452.A). The AWBA's Facility Inventory (1997) concluded that the Tucson AMA lacked sufficient recharge capacity to meet the goals of the AWBA.

The final product of the Regional Recharge Planning Process was the Regional Recharge Plan (IPAG, 1998). That document contains background material, analysis and specific policy recommendations. Both the Plan and the Process have been held up as exemplars of what recharge planning efforts can achieve.

AVID Proposal

Following the publishing and distribution of the 1998 Plan, IPAG was inactive. But in March, 2000 IPAG reconvened to evaluate a proposal involving construction of a pipeline from the CAP canal to the Avra Valley Irrigation District (AVID) Groundwater Savings Facility. Like all GSFs, AVID would use a renewable supply—CAP in this case—to grow crops that would have otherwise been irrigated with groundwater. The CAP water offsets groundwater use and is identical, from a legal perspective, to CAP stored in a direct recharge facility (e.g., spreading basin, injection well, etc.). Storage at GSFs is also inherently less expensive than direct storage since the farm or district receiving the CAP is willing to pay some portion of the storer's cost of the water, whereas direct facilities have overhead expenses that the storer must pay in *addition* to the cost of the water.

The AVID facility had been permitted in 1998, but did not have delivery infrastructure to receive CAP water in lieu of groundwater. Herb Kai of AVID, working with consultant Mark Meyers, presented a draft concept in which a pipeline would be built and irrigation ditches rehabilitated. The AWBA would plan to store 5,000 acre-feet per year for 5 years at the facility. AVID would pay the AWBA's customary $21/AF GSF water charge, but the AWBA would pay an estimated $16/AF to $17/AF "facility fee" to offset the cost of the new infrastructure. The net cost of storage would still be lower than at any direct recharge facility and the AMA's total recharge capacity would be increased. Adding an extra potential benefit, the pipeline could be designed to allow stored water to be recovered (pumped) near to where it had been stored, then delivered back into the CAP canal for 'downstream' users in times of outage or shortage on the CAP system.

The AVID proposal received mixed reviews. There were individual elements of the proposal that appealed to most observers, including onsite recovery, additional capacity, and lower cost credits. There was also some thought that this innovative

arrangement could be a model for other projects in which CAP infrastructure was needed. But there were also many questions and concerns, some specific to the project (cost estimates, risk, contract language, easements, ownership, etc.), and some related to how the project fit with the region's overall needs (facility location, capacity sufficiency, "firming" requirements, GSF vs. USF, etc.). IPAG raised some initial concerns, but also recommended that Mr. Kai proceed with further discussions with the AWBA to refine the concepts. IPAG also agreed to conduct further assessments of the broader issues.

Recharge Facilities

Recharge has been the sole means by which CAP has been put to use in the Tucson AMA since Tucson Water's ill-fated experience with direct-delivery ended in 1994 (Figure 1). Since that time, the number, type and capacity of storage facilities has grown to the point where local storers have multiple options. Indeed, the region has permitted recharge capacity that appears to be sufficient to meet both local storage needs and those of the AWBA. But those broad impressions are considerably less clear when scrutinized. For instance, there can be substantial differences between the permit volume and the actual operational capacity. In the case of two facilities—AVID and Farmer's Investment Company (FICO) GSF—the operational capacity is zero because no delivery infrastructure is in place.

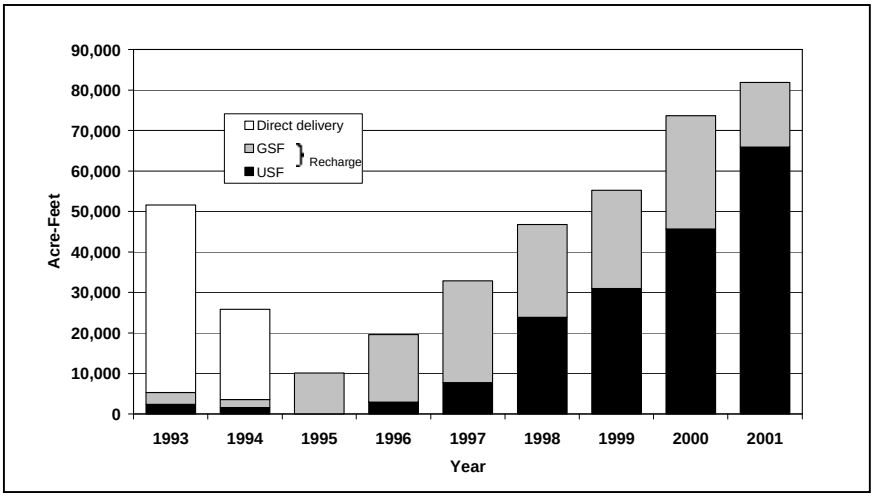

Figure 1. CAP utilization, by type and year, in the Tucson AMA.

Complicating the question of capacity is the very significant degree of uncertainty regarding future recharge by municipal water providers. The role of Tucson Water, which serves three-quarters of the AMA's population, is particularly important. The city provider may have to overcome legal and political hurdles if it is ever to return to direct delivery. Even though the debate over recharge versus direct delivery has lost much of its acrimonious tone, the issue remains politically sensitive. If Tucson Water does not return to direct delivery, it will likely need additional recharge capacity; if direct delivery does return, significant capacity could be freed up. In the meantime, Tucson Water has

invested heavily in recharge, particularly at its Clearwater Renewable Resource Facility (formerly CAVSRP).

Regional Recharge Plan

The 1998 Regional Recharge Plan served as the starting point for evaluation of the AVID proposal and of the region's overall needs. The Plan contains three ten-year projection scenarios (Low, Medium and High Demand) that model four principal variables (Tucson Water demand; other provider demand; rates of long-term storage credit accrual; and AWBA demand). The variables were combined in such a way that the High and Low Demand scenarios were not themselves particularly likely, but rather were "…meant to frame the possible low-end and high-end conditions that may define future recharge demand" (IPAG, 1998).

The scenarios were the result of careful and thoughtful work, and were sufficient to support a number of important conclusions and policy recommendations. But the scenarios were based on a small number of variables that had been simplified and aggregated in a way that made it difficult to assess the relative contribution of each.

In the more recent IPAG effort, members discussed whether they wanted to fully update the1998 Plan. There was some conceptual support for this idea, but reluctance to tackle such a potentially large undertaking. Furthermore, the bulk of the Plan remained relevant and useful. Unfortunately, the scenarios were of limited use. Not only had many of the underlying conditions changed, but the level of generalization was too high to address the questions with which IPAG was now grappling. In particular, financial and operational variables needed to be analyzed. With that in mind, IPAG tasked a sub-group to proceed with initial data collection and analysis.

Policy Variables

In their most derivative state, many recharge policy variables can be expressed as simple equations. Credit generation, for instance, can be represented as a function of the cost of water, facility fees (or contribution, in the case of GSFs) and a cut to the aquifer. So the first attempt at analysis began as a rather ordinary spreadsheet. The revenue streams and overall storage options for the AWBA were modeled quite simplistically in Microsoft Excel™. This straightforward approach began to reveal some of the key relationships, but also the obvious limitations.

As required by statute, the AWBA is last in priority for storage, so both its annual costs and its available capacity can be assessed only after all other storage has been taken into account. Further analysis would either have to rely on highly generalized scenarios, like the 1998 Plan, or many more of the key variables would have to be modeled. The list of factors to consider in a more thorough analysis was considerable, and included both financial and operational variables (Table 1). The underlying assumptions can vary widely and it is not unusual for projection estimates for individual variables to vary by 50% or more.

Policy variables of the type in Table 1 are most often collected, analyzed and displayed in tabular format. While such 'spreadsheet analyses' may be adequate, they stand in stark contrast to more sophisticated and informative decision-support tools used

in other aspects of regional water planning. Groundwater flow models and Geographic Information Systems, for instance, have played an increasingly prominent role in planning, often to great effect. But the software tools available for financial or other types of policy modeling are less developed, integrated or standardized. In the IPAG effort, the large degree of uncertainty, coupled with the dynamic and interrelated nature of most of the key variables, argued for creation of an analytic tool that was highly adaptive.

Financial, by year	
• Cost of water	• Withdrawal Fees to AWBA
• Cost of storage, by facility	• General Fund to AWBA
• Property tax to AWBA	
Operational, by year and facility	
• Permitted volume	• Storage by local storers
• Operational volume	• Storage available to AWBA
Other	
• Total demand by provider	• Historic use
• Total demand for recharge	• Storage preferences

Table 1. Selected recharge policy variables

Recharge Analysis Tool

In spite of limitations, the initial work on the AWBA spreadsheet had shown enough promise that the choice was made to continue development in Excel. The intrinsic capabilities of Excel would be exploited and custom programming in Visual Basic™ would extend the functionality. The goal was to improve the level of analysis by building a tool that would model the complex variables in an interactive and visually compelling manner.

Microsoft Excel is not an ideal modeling or application development platform, but its capabilities are more substantial in this regard than is commonly recognized. Its core spreadsheet functions, (e.g., cell-based calculations, absolute and relative cell referencing, conditional statements, etc.), can be enhanced with interactive control elements (e.g., buttons, "spinners," dialog boxes, etc.), dynamic graphing, and advanced formatting. And Excel's integration with Visual Basic, (implemented through macros), allows virtually unlimited options for extending functionality, albeit in a less "user-friendly" manner.

The components of the expanded spreadsheet analysis were spread across six separate sections (pages), accessed by selecting tabs at the bottom of the screen. The pages are examined and manipulated in any order, though there are factors in 'later' pages (e.g. Storage) that are derived from 'earlier' pages (e.g. Demand). The pages are:

Demand—Total demand projections are set by sector, provider and year. The percentage of demand met with CAP recharge is also set.

USFs—Operational capacity, by year, for Underground Storage Facilities (i.e. direct recharge projects) is specified.

GSFs—Operational capacity, by year, for Groundwater Savings Facilities (i.e., in lieu recharge projects) is set.

AWBA—Factors relevant to storage by the Arizona Water Banking Authority, including projections of revenue and interstate storage are specified.

Storage—Storage for each storer is specified, by facility and year. Annual facility capacity is linked to USF and GSF sections. Providers' recharge demand is linked to Demand section.

Summary—Summarizes information specified in the other pages, including a map/graph representation of AWBA storage. In addition, users can load or delete previously saved scenarios, or save the current scenario.

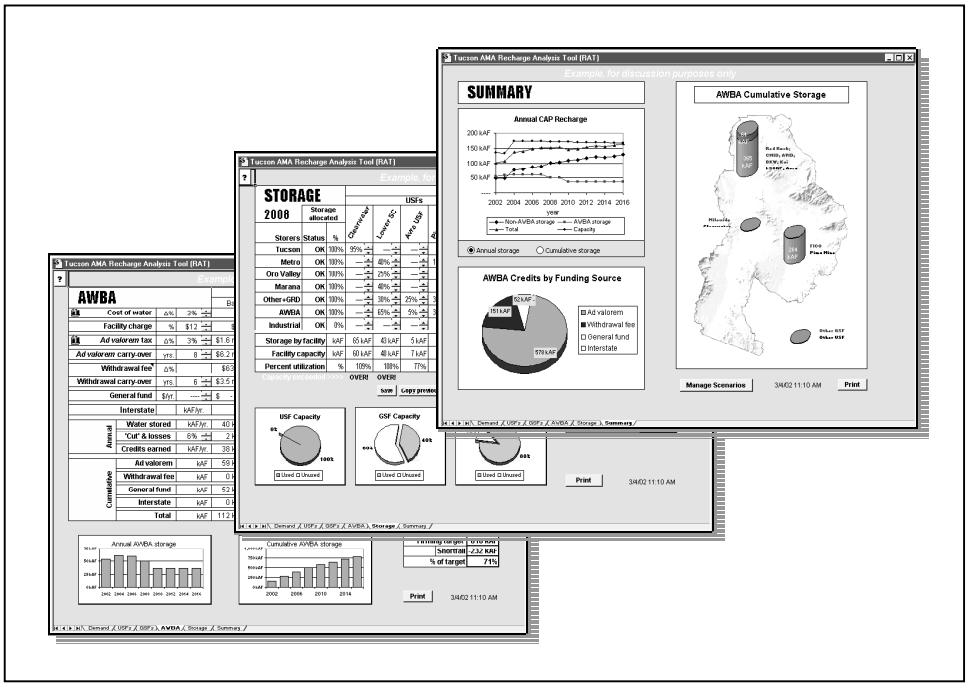

Figure 2. Sample screens from the Recharge Analysis Tool

The principle way users interact with the tool is by clicking on small buttons adjacent to the variables. These incremental adjustments to baseline values automatically update all related values (including those in other sections), and summary charts display the changes as well.

As the underlying mechanics of the analytical tool were built, attention was paid to visual representation. To help organize the on-screen information, cells were color-coded: yellow for user-specified data; blue for automatically calculated fields; and green for totals and subtotals. Each page also has a help screen, and some screens also have

icons that can be clicked to display a chart of relevant data. These charts display both historic and projected data concurrently for comparison purposes.

The result is an overall look-and-feel that belies its spreadsheet underpinnings (Figure 2). Dubbed the "Recharge Analysis Tool" the final application allows users to model recharge activity of seven different storers, at twelve facilities, through the year 2016 (the AWBA's statutory sunset year) (Tucson AMA, 2002).

With the tool fully operational, a "most likely" scenario was developed by the IPAG sub-group. Projected values were based on general knowledge of provider characteristics, historic trends, and data compiled as part of a recent groundwater modeling effort. The "base" scenario was then presented to the larger group.

Scenario Testing and Refinement

IPAG's review of the base scenario refined the assumptions, built confidence in how the model worked, and perhaps most importantly, allowed the group to seamlessly move from minor assumption tweaking to full scenario testing and sensitivity analysis. This ability to instantaneously modify scenarios not only greatly reduced the amount of time normally devoted to scenario refinement, it helped foster an almost intuitive sense of how the modeled variables interact with each other. This process also altered the nature of the discussion on several policy issues.

One of the principal ways the model was used was to evaluate the amount of "firming" the AWBA would be able to do in the AMA. Firming is the water required to satisfy the demand of CAP subcontractors during times of shortage and outage on the CAP system, for a 100-year period. The AWBA had estimated that the Tucson AMA had firming requirements of some 810 kAF.

Lowering average storage costs is one strategy for meeting the firming target, and the tool was used to model the effect that GSFs (which are less expensive than direct facilities) could have on the amount stored. But greater utilization of GSFs like AVID was not a strategy favored by all IPAG members. As was true in 1998, there was agreement that all projects needed to be evaluated on a case-by-case basis. But the language in the 1998 Plan artfully finesses the more controversial aspects;

> *"There are some weaknesses of in-lieu recharge relative to direct recharge…. However, the benefits of some GSF's may outweigh those of some USF's [direct facilities] due to lower cost or local contributions to water management goals."*

The analysis revealed that the region was going to come up short on credits virtually regardless of the GSF utilization rate. That conclusion was not entirely new or unexpected, but the model crystallized and quantified it. The base scenario showed a 232 kAF (29%) firming shortfall, and the earlier rounds of tweaking had shown that number was relatively insensitive to changes in assumptions. The shortfall remained above 150 kAF even when low probability assumptions were used. The interactive analysis had not resolved the philosophical differences over the role of GSFs, but it had downplayed the significance of the issue.

After several sessions using the tool, work on additional scenarios was put on hold. The group felt that the analysis had revealed enough to make some specific policy observations and recommendations.

Policy Recommendations

IPAG shifted its attention to a series of presentations to the AWBA, Central Arizona Water Conservation District (i.e., CAP) and the Tucson AMA Groundwater User Advisory Committee. IPAG members were particularly keen to make those bodies aware of the quantification of the firming shortfall and the likelihood that multiple approaches would have to be employed to bridge the gap.

Once again too, IPAG was requested to provide input on the AWBA Facilities Inventory (2002), which was due for its five-year update (A.R.S. 45-2452.F). IPAG members expressed some uncertainty as to whether the capacity added since the 1997 Inventory was truly sufficient for the next ten years. But the final conclusion was that sufficient capacity *had* been built to meet both local storage needs and those of the AWBA, *based on the expected revenue and cost of storage.* This somewhat nuanced position resulted from the analysis, which had made it clear that inadequate revenue and high storage costs would likely constrain storage before physical capacity did. Additional facilities could lower some costs, or create improved water management benefits (based on facility location), but the firming shortfall would remain.

Meanwhile, the group attempted to come to final resolution on the AVID proposal. In 2002, Mr. Kai presented engineering estimates of cost that were notably higher than had been originally estimated. The onsite recovery provisions had also been scaled back, making the benefits less direct and attractive. Many of the elements of the proposal remained desirable, but ultimately the group decided that it was not going to be able to reach a clear consensus recommendation.

Conclusions

Regional recharge issues are tied to both broad policy questions and detailed technical analysis. Policy variables are inherently messy and complicated, and planning efforts are often difficult, slow and contentious. IPAG's experience reaffirmed those unfortunate attributes, but also demonstrated that modeling tools can assist in the evaluation of policy options. Consensus may still prove elusive, as was the case with the AVID proposal, but IPAG's effort led to important insights, shared understandings and substantive policy recommendations.

Interest in regional recharge and recovery planning has fluctuated over time. The Governor's Water Management Commission (2001) made a specific recommendation to initiate recovery planning, and the AWBA, CAWCD and ADWR are taking steps to do additional recharge and recovery planning. The critical water management and public policy implications of recharge and recovery justify support of these efforts and, where appropriate, development of tools like those used by IPAG.

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